INDEX OF AUTHORS

VOLUME XLIII

TRANSACTIONS OF AMERICAN SOCIETY FOR METALS

1951

A

Adenstedt, Heinrich 873
Averbach, B. L. 497, 1072

B

Baldwin, W. M., Jr. 778
Balluffi, R. W. 497
Beck, F. H. 404
Bernstein, Harold 635
Bever, M. B. 342, 378
Bindari, A. E. 226
Binder, W. O. 759
Boss, G. H. 122
Brooks, H. E. 547
Buffum, D. C. 644
Burns, Jay R. 873
Busby, P. E. 526

C

Carapella, S. C., Jr. 853
Carney, D. J. 480
Childs, W. J. 105
Clark, D. S. 571
Cline, J. E. 105
Cohen, Morris 497, 1072

D

DePierre, Vincent 635
Dorn, J. E. 611
Dulis, E. J. 692

E

Eberly, W. S. 243

F

Faupel, J. H. 993
Floe, C. F. 342, 378
Fontana, M. G. 404, 547, 1098

G

Geisler, A. H. 70
Gilman, J. J. 161
Gittings, D. O. 587
Grant, N. J. 824

H

Harris, W. J., Jr. 1175
Hausner, H. H. 1052
Hayes, E. T. 888
Huntoon, R. T. 426

J

Jaffe, L. D. 644
Janulionis, A. D. 480

K

Kinsey, H. V. 193
Kisner, W. M. 105
Klier, E. P. 935, 1033
Klimas, C. V. 526
Koh, P. K. 226

L

Larson, Hugo 1033
Lement, B. S. 1072
Light, J. O. 323
Loria, E. A. 718

M

Mack, J. O. 587
MacMillan, J. A. 692
Mahla, E. M. 290
Marin, Joseph 993
Miller, O. O. 260
Moeller, R. D. 39
McAdam, D. J., Jr. 970, 1215
McCullough, H. M. 404
McPherson, D. J. 1098

N

Nicholson, M. E. 142
Nielsen, N. A. 290

O

O'Brien, W. L. 888

P

Peretti, E. A. 853
Phebus, R. L. 811
Pinto, N. P. 1052
Piper, T. E. 1013
Post, C. B. 243
Potter, R. D. 824
Putman, J. W. 824

R

Rengstorff, G. W. P. 342, 378
Rinebolt, J. A. 1175
Ripling, E. J. 778
Roberson, A. H. 888
Rogers, W. T. 1126
Rowland, D. H. 587

S

Schonfeld, F. W. 39
Sherby, O. D. 611
Shortsleeve, F. J. 142
Smith, E. C. 651
Smith, G. V. 692
Speiser, Rudolph 734
Spendelow, H. R., Jr. 759
Spretnak, J. W. 547, 734
Stanley, J. K. 426
Stewart, M. T. 193
Sullivan, A. M. 906

T

Tarasov, L. P. 1144
Tipper, C. F. 906
Tipton, C. R., Jr. 39

V

vonHoene, J. 426

W

Waber, J. T. 39
Wells, Cyril 526
Wilder, A. B. 323
Wilson, William, Jr. 454
Wood, D. S. 571
Worden, C. O. 958
Wulff, John 105

Z

Zapffe, C. A. 811, 958
Zmeskal, Otto 226

SUBJECT INDEX

Activation energy
stainless steels 405, 419-420
type 304 419
type 410 419-420
type 430 419
steel
for isothermal grain growth 279-280

Adhesion
of molybdenum coatings
to copper 120-121
to nickel 115-121
to steel 115, 120-121

Allotropy
of silver chloride 58

Alloying
of silver chloride 58-61

Aluminum
role in magnet alloys 77
ultimate stress
effect of temperature .1217-1218

Aluminum alloys
Alcoa 2S
stress-strain energy relationship 1215-1242
ultimate stress
effect of temperature 1217-1218
yield stress
effect of temperature 1217-1220
Alcoa 2S-O
stress-strain relations for biaxial tension-compression stress. See under Stress-strain relations.
copper-magnesium alloys (24S)
retained ductility .779-780, 788
copper-magnesium alloys (24S-T)
stress-strain relations for biaxial tension-compression stress. See under Stress-strain relations.
tensile and fatigue properties
effect of notches at 25 °C and —196 °C...547-569
creep properties
Al-H12 615-627

Aluminum alloys (cont.)
creep properties
Al-H18 615-623
2S-H12 .....618, 623-625
2S-H18 .....613-615, 619, 625
2S-O 628-630
4S-H32 .....620, 626-627
4S-H38 .....620, 621, 627
magnesium alloy (52S)
recovery and cold working of 122-138
mechanical properties 613
Al-H12 613
Al-H18 613
2S-H12 613
2S-H18 613
4S-H32 613
4S-H38 613
zinc-magnesium-copper alloys (75S)
fractographic study of fatigue 958-968
hot forming of 75S-T6 1013-1032
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C.547-570

Aluminum coating
on steel 587-605
adherence of coating 588
alloy layers 587-588
bending properties of coating 602-605
effect of alloying elements 603-605
effect of beryllium 604
effect of copper 604
effect of silicon 604
cracking
definition 604
ductility of aluminum..604-605
effect of beryllium ..604-605
effect of silicon 604-605
ductility of coating..... 588
effect of thickness on ductility 588
flaking
definition 604
methods of coating..... 587

Aluminum coating (cont.)
on steel
microhardness of the alloy layer 595, 599-602, 605
effect of alloying elements 595
effect of beryllium 595, 599-602, 605
effect of copper 595, 605
effect of silicon 595, 599-602, 605
relationship to thickness 599-600
peeling
definition 604
procedure 589-590
surface appearance.591-592, 605
effect of alloying elements 591-592, 605
thickness of alloy layer.. ..588-589, 593-600, 605-607
effect of alloying elements 593-599
effect of bath temperature 588
effect of beryllium 594-596, 598-599, 605, 606
effect of cooling rate .. 588
effect of copper 594-599
effect of silicon 589, 594-597, 599, 605, 607
effect of time of immersion 588
relationship to microhardness 599-600

Aluminum-silicon alloys
grain refinement of 635-643

Aluminum-silicon-magnesium alloys
grain refinement of 635-643

Annealing
of Alcoa aluminum alloy 52S
effect of temperature on grain size 130-138
effect of temperature on properties 124-129
effect of time 126-127
silver chloride 52-54
steels, high chromium
effect of annealing temperature on relative magnetic susceptibilities 188

Annealing (cont.)
steels, high chromium
effect on grain size 181
influence on rate of sigma formation 181, 185-186
relationship of initial ferrite content and annealing temperature 181

Annual Address of the President 7

Annual Dinner of ASM 23

Annual Meeting of ASM 7

Annual Report of the Secretary 15

Annual Report of the Treasurer 11

Austenite transformation
in chromium-molybdenum-manganese steels
TTT diagrams 725-729
in nickel-chromium-molybdenum steels
TTT diagrams 721-725

Austenitic stainless steels
See also Stainless steels.

Beryllium
in aluminum-silicon alloy
effect on grain size ...639, 642
in aluminum-silicon-magnesium alloy
effect on grain size 640-641
ductility 1053
metallography of powdered compacts 1068
powder metallurgy 1052-1069
bend tests of sintered compacts 1063-1064
electrical resistivity of specimens 1064
cold rolling of sintered compacts 1064-1067
effect of annealing.1065-1066
influence on microstructure 1065-1066
compacting 1056
electrical resistivity of sintered compacts 1060
hardness of sintered compacts 1067-1068

Beryllium (cont.)
powder metallurgy
microstructures of sintered compacts 1060-1063
effects of sintering temperature 1061-1062
sintering
in argon 1057
effect of sintering temperature on density..1057-1058
effect of sintering temperature on electrical resistance 1057, 1060
evaporation of beryllium 1059-1060
in vacuum 1057
recrystallization temperature 1065-1066

Biaxial tension-compression stresses
applied to aluminum alloys 2S-O and 24S-T
effect on mechanical behavior 993-1012

Biringuccio's lodestone 670

Boron
in aluminum-silicon alloy
effect on grain size ...639, 642
in aluminum-silicon-magnesium alloy
effect on grain size.638, 640-642

Brass
ultimate stress
effect of temperature.1217-1218

Brassert-Cape furnace 666-667

Bromine-methanol method
of isolating carbides in stainless steel 293, 312, 316-317

Cadmium-zinc
constitution diagram 854

Carbide isolation
methods 293
bromine-methanol technique 293, 312

Carbon
in chromium steels
effect on toughness .....
.....764-769, 771-777

Carbonitriding
advantages claimed for ..348-349
carbon sources 347
composition of cases
austenite (retained) gradients 395-397
procedure for determining 395
carbon gradients .....
.....383-386, 394-396
effect of temperature of carbonitriding 383-386
effect of temperature of carbonitriding 347, 367
nitrogen gradients .....
.....382-386, 394-397
effect of temperature of carbonitriding 383-386
constitution of cases 378-397
effect of temperature of carbonitriding ..389-393, 396
effect of tempering 389-393
literature survey 378-381
phases by X-ray diffraction .389-393, 396-397, 400-402
procedure for determining 381-382, 386-388
depth of case
effect of temperature of carbonitriding .....
.....352-353, 358, 361-362
effect of tempering 363-365
effect of time of carbonitriding 358-359
effect of water vapor.... 360
depth-hardness
effect of temperature of carbonitriding 355-356
epsilon carbonitride phase..
..... 379-380, 389-390
preferred orientation ..389-390
exhaust gas
composition 360
furnace, diagram 351
history and development.343-344
microhardness of case
effect of temperature of carbonitriding .....
.....355, 360, 363-365
effect of tempering....363-367
effect of water vapor ... 360

Carbonitriding (cont.)
microstructure of case 352-356, 359-360, 362-363, 365, 371-376
effect of cooling rate ..362-363
effect of gas composition 359, 371-374
effect of temperature of carbonitriding 352-356
effect of tempering 362, 363, 365
effect of water vapor ... .359, 360, 371-376
microstructure of core ..366, 368
effect of cooling rate..366, 368
effect of temperature of carbonitriding 366
nitrogen sources 347
process 342-352
relation to carburizing and nitriding 344-348
surface hardness of case
effect of cooling rate...362-363
effect of gas composition. 359
effect of temperature of carbonitriding 356-357
effect of tempering 366-367

Carbon-molybdenum steels
Charpy impact
after exposure to elevated temperatures 333

Carburizing
effect of water vapor 345
energizers 343, 346
process 344-345
relation to carbonitriding and nitriding 344-348
temperature 345

Castings
of silver chloride 48-51

Cementite
crystal structure ...379, 394, 395

Charpy impact
after exposure at elevated temperatures 333-335
carbon-molybdenum steels 333
chromium-molybdenum steels 333
chromium-molybdenum-vanadium steels 333
exposure factors 334

Charpy impact (cont.)
after exposure at elevated temp.
molybdenum-vanadium steels 333
steel, SAE 3140 646-648
titanium-chromium alloys 1114-1115

Charpy impact properties
pearlitic steels 1175-1214

Chromium
in aluminum-silicon alloy
effect on grain size ...639, 642
in aluminum-silicon-magnesium alloy
effect on grain size ...638, 640
effect on mechanical properties of chromium steels 761-764, 771
as function of carbon and nitrogen contents 765-767, 771
effect on transition temperatures of chromium steels 769-772
melting point 1098
role in retarding softening of steel 514-516, 521, 524

Chromium carbide
crystal structure 318-320

Chromium-iron 142-143
phase diagram 143

Chromium-molybdenum
constitution diagram 826-827

Chromium-molybdenum-iron
constitution diagram. See under Constitution diagrams.

Chromium-molybdenum steels
creep-rupture properties .340-341
effect of molybdenum ... 340
elevated temperature tests 327, 331-333, 337
decarburization 327
effect of post-welding heat on graphitization .331, 332, 337
graphite rating of welds. 327
effect of aluminum deoxidation ..327, 334, 336, 337
effect of molybdenum variation 327
photomicrographs ...328-329

Cr-Mo steels (cont.)
elevated temperature tests
hardness 334
oxidation 327, 332
sigma phase 330
spheroidization 327-329
tensile properties 339
microstructure
effect of elevated temperatures on carbides ...327-328

Chromium-molybdenum-vanadium steels
Charpy impact
after exposure to elevated temperatures 333
elevated temperature tests 331-335
graphitization 331, 335
hardness 334
oxidation 332
spheroidization 331

Chromium-nickel-molybdenum steel
sigma phase
etchants 164
microstructures 164-165

Chromium steel
carbide precipitation 144-145
relationship to formation of sigma 144-145
chromium-iron carbide
rate of formation .144-145, 154
compositions 144
ferrite to ferrite plus sigma 146-148, 154, 155
rate of reaction 146-148, 154, 155
effect of carbon .147, 148, 155
effect of temperature .. 147
time-temperature transformation curves 148
ferrite/ferrite plus sigma boundary.145-148, 150-152, 154, 158
determination 145-146
heat treatment to establish 145
influence of carbon 150, 151, 154, 158
influence of manganese.. .....151, 152, 154
influence of minor elements 150-152

Chromium steel (cont.)
ferrite/ferrite + sigma boundary
influence of nitrogen ... 158
influence of silicon 151, 152, 154
influence of temperature 147, 148
sigma phase
embrittlement 158
solubility of carbon in.150, 151
sigma phase formation
threshold time 145, 148-150, 153-154, 156-158
effect of carbon 153, 154, 156
effect of chromium 147-149, 154, 157, 158
effect of cold work ... .145, 149, 150
effect of manganese .. 154
effect of pretreatment 159-160
effect of silicon 154
effect of temperature 148-149
temperature of minimum 149
tempering. See under Tempering of

Chromium steels, plain
effect of carbon on toughness 764-769, 771-777
photomicrographs 769
effect of chromium on mechanical properties ..761-764, 771
as function of carbon and nitrogen contents 765-767, 771
typical microstructures 761-762
effect of chromium on transition temperatures ...769-772
effect of nitrogen on toughness 764-769, 771-777
as function of heat treatment temperature ..773-777
photomicrographs 769
effect of oxygen on toughness 773-777

Cleavage fracture
in silicon-ferrite. See under Fracture.

Cleavage planes
in fractured ferrite 950-953

Cleavage surfaces
in ferrite
electron microscope examination 937, 945-946
experimental procedure for determining 936-937
fibering 939-952
fractographic examination 941-953
metallographic examination 937, 946-948
planes of cleavage.....950-953
plastically deformed metal forms of 937-952
slip planes in ferrite...952-953
X-ray examination 935-953

Coating
molybdenum. See Molybdenum plating.

Cobalt
role in magnet alloys.....77-79

Coefficient of expansion
of magnesium alloys
dilatometric determination of 876-878

Coefficient of surface heat abstraction
use in determining H factor 480-496

Coercive force
definition of 72
of permanent magnet materials 72

Cold work
of silver chloride 51
effect on hardness 45-46

Columbium
in aluminum-silicon alloy
effect on grain size 639
in aluminum-silicon-magnesium alloy
effect on grain size....638, 640

Composition
of permanent magnet materials 71

Constitution
of permanent magnet alloys
Alnicos 73-74, 78

Constitution (cont.)
of permanent magnet alloys
Cunico 85-86
Cunife 85-86

Constitution diagrams
cadmium-zinc 854
chromium-molybdenum .826-827
chromium-molybdenum-iron
chemical analysis 831-832
extent of sigma phase..842-846
effect of aging at 900 °C 846
iron-chromium sigma phase
effect of molybdenum on high temperature stability 844, 846-847
effect of molybdenum on interplanar spacing 841-842, 845
isothermal sections
at 900 °C ..838-842, 850-851
at 1100 °C ..836-837, 839-841
at 1300 °C 834-838
metallographic analysis 830-833
typical microstructures 837-838, 840-841, 843
thermal analysis of 829-830
liquidus temperatures.833-835
thermal treatments
effect on solid phase distribution 834-842
X-ray diffraction analysis 831-833
data on Fe_3Mo_2 .833, 840-841
data on iron-molybdenum sigma phase 833-834, 841-842
indium-cadmium 854-856
indium-cadmium-zinc
chemical analysis 857, 862
hardness survey 863-864
metallographic analysis 859-860, 864-868
one-phase limits 859-860, 864
typical microstructures 866-868
phase fields at room and eutectic temperatures.864-866
ternary eutectic composition 860
microstructure 868
thermal analysis of 857-862, 868-870

Constitution diagrams (cont.)
indium-cadmium-zinc
thermal analysis of
distribution of phases 858-862
liquidus temperatures. 869-870
type of system 864
X-ray diffraction analysis 860-867
data on interplanar spacings 862-863
extent of two-phase regions 861-867
indium-zinc 856
iron-chromium 143, 827
iron-molybdenum 825-826
nickel-aluminum 201-202
zirconium-iron 901-903
development of diagram
alloy preparation ...890-892
composition of alloys used 891
by metallographic examination 892-896
by thermal analysis..892-896
by X-ray studies ...894-897
differences compared with earlier work 901-902
eutectic 896, 901-902
eutectoid 894, 901-902
gamma field (Zr_2Fe_3) 897
maximum solubilities
in alpha field 892-893
in beta field 894-895
previous work 889-890
solidus line 896, 901-902

Constitutional diagrams. See also Constitution.
silver chloride 59-61

Cooling curves
use in determining H factor 482-492
use in new hardenability test 459-465

Copper
role in magnet alloys 81-82
ultimate stress
effect of temperature 1217-1218

Corrosion resistance
stainless steel, type 304
effect of cold work 310-312

Corrosion resistance (cont.)
stainless steel, type 304
effect of heat treatment 310-312
effect of interrupted quench from annealing temperature on 305
effect of sensitization temperature 294-299

Creep
aluminum alloys 611-634
Al-H12 615-627
creep strain as a function of time 616
effect of cold work..615-627
effect of stress 616
effect of temperature .. 616
secondary creep rate versus stress 615-622
secondary creep rate versus temperature 615-622
stress-rupture characteristics 622
Al-H18 615-623
creep strain as a function of time 617
effect of cold work ..615-627
effect of stress 617
effect of temperature.. 617
secondary creep rate versus stress 615-623
secondary creep rate versus temperature 615-623
stress-rupture characteristics 623
2S-H12 .....618, 623-625
creep strain as a function of time 618
effect of cold work ... .618, 623-625
effect of stress 618
effect of temperature.. 618
secondary creep rate versus stress 624
stress-rupture characteristics 624
2S-H18 .....613-615, 619, 625
creep strain as a function of time 619
effect of cold work ... .619, 623-625
effect of stress..613-615, 619

Creep (cont.)
aluminum alloys
2S-H18
effect of temperature.. .....613-615, 619
secondary creep rate versus stress 625
stress-rupture characteristics 625
2S-O
effect of annealing temperature 629-630
effect of grain size ..628-629
4S-H32 .....620, 626-627
creep strain as a function of time 620
effect of cold work ..620, 627
effect of stress 620
effect of temperature .. 620
secondary creep rate versus stress 626
stress-rupture characteristics 626
4S-H38 .....620, 621, 627
creep strain as a function of time 621
effect of cold work ..620, 627
effect of stress 621
effect of temperature.. 621
secondary creep rate versus stress 627
stress-rupture characteristics 627

Creep properties
aluminum alloys
effect of cold rolling on 611-634
mechanisms of 617-627, 633
specimen 614
stress versus logarithm of secondary creep rate 630-633
threshold stress 632
effect on solidus temperature determinations with dilatometer 880-886

Creep-rupture test
nickel-aluminum-molybdenum alloys 194-199, 215-216
specimen 195

Crystal recovery
aluminum, 2S
after cold work 1240-1242

Crystal structure
cementite 379
iron carbide 379
iron-nitrogen phases 379-380
martensite 381
silver chloride 58

Curie point measurements
in studying tempering of chromium steels 498, 501, 509, 516

Curie temperature
Invar
effect of carbon content.. 1089-1090

Debye patterns
sigma phase 234-235

Deep hardening steels
hardenability test. See Hardenability test.

Deformation
of Alcoa aluminum alloy 52S
differences in during rolling and stretching 122-139

Density
chromium 1098
titanium 1098

Diffraction patterns
titanium-chromium alloys 1121

Diffusion
mechanism of 735

Dilatometer
use in determining solidus temperatures of magnesium alloys. See under Solidus temperatures.
use in studying tempering of chromium steels 498-502, 505-508

Direct temperature factors
aluminum, 2S 1220
influence of plastic strain 1222-1224
copper 1220-1221
duralumin 1220
effect of prior plastic strain 1220
Monel 1220-1221
nickel 1221

Domnarvet furnace 669

Ductility
beryllium 1053-1054
of chromium steels. See Chromium steels, plain.
steel, SAE 3140
effect of strain rate ...644-650
transverse of wrought steel products
effect of reheat treatment on. See Reheat treatment.

Ductility, retained
definition of 778-779
versus prestrain in steel 779-810
two basic types of behavior 779

Duralumin
ultimate stress
effect of temperature 1217-1218, 1220
yield stress
effect of temperature 1217-1218, 1220

Election of Officers 22

Electrical resistance
of silver chloride 63-64

Electrolytic method
for extraction of carbides in chromium steels 512-515

Electron microscope
use in studying cleavage surfaces in ferrite 937, 945-946
use in studying tempering of chromium steels 510-511, 518-519

Electron microscopy
preparation of specimens 293-294

Elevated temperature
forming of aluminum and magnesium alloys. See under Hot forming of.

Elevated temperature properties
carbon-molybdenum steels 327-329, 331-334, 336-337
chromium-molybdenum steels 327, 330-335, 339-341
chromium-molybdenum-vanadium steels 331-335
molybdenum-vanadium steels 327, 330-333, 337

Elevated temp. properties (cont.)
nickel-aluminum-molybdenum alloys 196, 215-218, 224
effect of molybdenum ... 196
fatigue 224

Embrittlement
of stainless steels
by normal moisture or steam in heat treating atmosphere
bar-bend test for 813
compositions of steels tested 813
experimental procedure 813-814
results for types 403 and 410 steels..814-815, 820-821
results for type 414 steel 815-817, 821
results for type 416 steel 818-821
results for type 431 steel 817-818, 821
results for type 440C steel 819-821
of steel
rheotropic. See Rheotropic embrittlement of steel.

Endurance limits
for ten engineering alloys at 25 °C and —196 °C, notched and unnotched ..556, 558-561
fatigue curves (S-N curves) 556-561

Energy product
definition of 72
of permanent magnet materials 72

Equilibrium diagrams
See Constitution diagrams.

Etch pits
in silver chloride 51

Expansion properties
type 430 stainless steel 248-249, 258-259
type 446 stainless steel 243-245, 257-259
effect of nitrogen in 245

Fabrication
of silver chloride 45-46

Fatigue
fractographic study of
fractographs of Alcoa 75S alloy 959-966
fractographs of SAE 1010 iron 966-967
fracture patterns
depth of patterns ...962-967
lamellar structure 962
materials studied 959
micellar theory as explanation for fatigue 967-968
correlation with damping behavior 968
platy structure 959-962
possible uses for 968
relationship to stage of fatigue ...962, 964, 967-968

Fatigue properties at low temperatures
of ten engineering alloys, notched and unnotched 556-566

Ferrite
cleavage surfaces in. See Cleavage surfaces.

Ferrite/ferrite plus sigma boundary
steel, chromium .....
....145-148, 150-152, 154, 158
determination 145-146
heat treatment to establish 145
influence of carbon .....
.....150-151, 154, 158
influence of manganese ..
.....151-152, 154
influence of minor elements
.....150-152
influence of nitrogen 158
influence of silicon 151-152, 154
influence of temperature
.....147, 148

Ferrite to ferrite plus sigma
steel, chromium..146-148, 154-155
rate of reaction .....
.....146-148, 154-155
effect of carbon 147, 148, 155
effect of temperature .. 147
time-temperature transformation curves 148

Ferritic stainless steels
See also Stainless steels.

Ferritic stainless steels, trade designation
type 446 243-259

Fibering
at cleavage surfaces in ferrite
.....939-952

Finishability
tool steels
effect of hardness ...1164-1165
surface roughness versus grindability index ..1163-1165

Flow stress
aluminum, 2S
influence of temperature
.....1224-1228, 1235-1236
primary curves 1224-1227
secondary curves .....
.....1225, 1227-1228
copper
influence of temperature
.....1235-1236
ratios 1222
influence of plastic strain 1222
in stressed metals
effect of temperature on 975

Flow stress ratios
aluminum, 2S
influence of temperature
.....1235-1236
copper
influence of temperature
.....1235-1236

Forgings
steel
effect of reheat treatment on transverse ductility. See Reheat treatment.

Fractography
use in studying cleavage surfaces in ferrite 941-953
use in studying fatigue fractures. See under Fatigue.

Fracture
fatigue
fractographic study of. See under Fatigue.
of silicon-ferrite crystals
material studied 908-909

Fracture (cont.)
of silicon-ferrite crystals
Neumann bands formed during 910-927
nature of Neumann bands 907-908
relationship to cleavage-type fracture 910-927
sequence of formation 926-927
structure at the end of cracks 923-926
structure of fractured surface 921-923
tensile results 909
types of fractures 906-907, 909-912
X-ray study of cleavage fractures 912-921

Grain boundary
adsorption of solute atoms 735-747
effect of temperature changes on 735-747
in producing temper brittleness 739-747
role in several grain boundary phenomena 738, 740
phenomena 734-735

Grain growth, rate of
steel
influence of austenitizing temperature 279-280
influence of grain size 278-280, 284

Grain refinement
aluminum alloys
preparation of specimens 636-637
aluminum-silicon alloys ..635-643
aluminum-silicon-magnesium alloys 635-643
microstructures 641

Grain size
aluminum alloys
2S-O
effect on creep resistance 628-629
aluminum-silicon alloys ..639-642
effect of beryllium on..639, 642
effect of boron on 639, 642

Grain size (cont.)
aluminum-silicon alloys
effect of chromium on 639, 642
effect of columbium on .. 639
effect of molybdenum on . 639
effect of tantalum on 639
effect of titanium on ..639, 642
effect of tungsten on 639
effect of zirconium on ... .639, 641-642
aluminum-silicon-magnesium alloys 638-642
effect of beryllium on ..640-641
effect of boron on 638, 640-642
effect of chromium on 638, 640
effect of columbium on 638, 640
effect of molybdenum on 640
effect of tantalum on 640
effect of titanium on ..640-642
effect of tungsten on 640
effect of zirconium on ... 640
of recrystallized Alcoa 52S alloy 127-138
after rolling 130-133
after stretching 133-138
effect of annealing temperature on 130-138
effect of type of deformation on 136-138

Grain size, austenite
steel
influence of austenitizing temperature 260-285
influence of austenitizing time 263-285
influence of carbides ..277, 285
influence of deoxidation practice 273-276, 285
influence of inclusions 273-276, 285, 289
influence of nitrogen 276

Graphitization
steel 692-711
carbon-stable rim 700-701, 705, 707-709, 715, 717
effect of oxygen penetration 709
diffusion process 700-701
nitrogen penetration 701, 703-704
oxygen penetration 704

Graphitization (cont.)
steel
effect of aluminum deoxidation 705-706, 709-710
effect of austenitizing atmosphere 693-695, 698-709
nitrogen atmosphere 701, 703, 705, 707-708
effect of austenitizing temperature 693-694, 696-699
effect of cold work 716
effect of graphitizing atmosphere 704
effect of graphitizing temperature 692-695
effect of initial microstructure 694
effect of stress 713-714
inhibition by penetration of nitrogen .....
...701, 703, 709, 711, 714-716
mechanism of effect of residual aluminum ...709-710

Grindability
tool steels 1144-1174
compositions 1147
depth of burn 1165-1166
method of determining 1165
effect of alloying elements 1154-1157
effect of chromium content 1154-1155
effect of hardness ...1159-1161
effect of martensitic matrix 1170, 1173
effect of quenching medium 1154
effect of vanadium content 1155, 1156
evaluation 1150-1154
procedure for evaluating 1146-1150
relation to wear resistance 1170, 1173
types of measurements ..
.....1149-1150
versus tool life 1171-1172

Grindability index
tool steels 1151, 1154-1165
definition 1151, 1154

Grindability index (cont.)
tool steels
effect of carbide hardness 1151, 1157, 1170-1171
effect of carbide segregation 1158
effect of carbon content 1156-1157
effect of chromium content 1154-1155
effect of cobalt content .. 1156
effect of columbium 1156
effect of hardness ...1160-1161
effect of molybdenum ... 1156
effect of tungsten ...1155-1156
effect of vanadium content 1155-1156
effect of wheel hardness 1161-1162
microhardness of carbide particles 1157
versus grinding energy 1151, 1159, 1161-1162
versus surface roughness 1163-1165

Grinding
sensitivity 1153-1154, 1166
effect of heat treatment 1154, 1166
relation to grindability index 1166
relation to grinding energy 1166
surface cracking 1165-1166
surface finish 1154

Grinding wheels
aluminum oxide versus silicon carbide 1158

Growth equations
for transformation curves in studying tempering of chromium steels 503-505, 508

Hardenability
of chromium-molybdenum-manganese steels ..720, 725-729
definition of 730
of nickel-chromium-molybdenum steels 721-725
relationship to isothermal transformation 730

Hardenability (cont.)
of steel
H factor. See H factor in hardenability of steels.

Hardenability test
for deep hardening steels 454-479
composition of steels tested 460
correlation with oil quenching practice 462, 468-472
correlation with quench cooling curves ..459-465, 471-472
details of test..455-460, 469-470
disadvantages of test..473-475
heat flow considerations 475
limitations of existing tests 454-455, 471-472, 479
operating procedure ...472-473
representative results 467-471, 476-479
reproducibility of test..475-479
scope of test 471
specifications of test 455

Hardness
beryllium compacts 1067
nickel-aluminum-molybdenum alloys 209-211
steels, high chromium 168-171, 173, 180, 183, 185-186
comparison of cast and wrought material ...183, 186
correlation with average austenite path 171
correlation with mean ferrite path 171
dependence on sigma distribution 171
effect of annealing 180
effect of holding at sigma formation temperature 190
effect of repeated recrystallization 185
mixed phase hardening 168-170
comparison with age hardening 169
microstructures showing 170
relation to sigma content 173
of ten engineering alloys
at room and lower temperatures 567
titanium-chromium alloys 1110-1111, 1113

Heating methods
for hot forming aluminum and magnesium alloys 1016-1021, 1027
comparison of methods 1022-1024

Heat of activation
for decomposition of retained austenite in chromium steels 504, 508, 513

Heat resistance
of zirconium-iron alloys 899-901, 903

Heat transfer equivalent, H. See H factor in hardenability of steels.

Heat transfer factor. See Coefficient of surface heat abstraction.

Heat treating atmospheres
embrittling effect on stainless steels
of normal air 814-821
of steam 814-821

Heat treatment
reheat treatment of wrought steel products
effect on transverse ductility. See Reheat treatment.

H factor in hardenability of steels
development of term, H
effect of variations in thermal diffusivity 494-496
procedure in determining 482-484
review of recent experimental work 480-482
variation of H
with size of quenched round 484-486, 492
explanation for 488-492
with temperature..484-486, 492
explanation for 488-492
within a single quenched round 484-486, 492
explanation for 488-492

High temperature
forming of aluminum and magnesium alloys. See under Hot forming of.

Hot forming of
aluminum and magnesium alloys (75S-T6 and AZ31X-h)
advantages 1013-1014, 1026-1027
savings in fabricating time 1024
applicability to other alloys 1026
comparison of heating methods 1022-1024
heating methods 1016-1019, 1027
electric resistance—effect of length on mechanical properties 1017-1018, 1020-1021
hot oil bath 1018-1019
hot forming temperature range 1014-1017, 1027
effect of temperature on properties 1015-1017
production applications 1024-1029
similarity to room-temperature forming of 75S-O 1015
temperature effects ..1019-1022

Hot hardness
steels, high chromium
correlation with average austenite path 171
correlation with room temperature hardness .. 171
effect of sigma formation 172
titanium-chromium alloys 1104-1105, 1110-1111

Hot strength
of zirconium-iron alloys 899, 903

Hydrogen embrittlement
of stainless steels. See Embrittlement.

Impact values
of ten engineering alloys at room and lower temperatures 567-568

Indium-cadmium
constitution diagram 854-856

Indium-cadmium-zinc
constitution diagram. See under Constitution diagrams.

Indium-zinc
constitution diagram 856

Interdiffusion
of molybdenum coatings
on copper 120
on nickel 115-120
on steel 115-120

Interplanar spacings
of indium-cadmium-zinc alloys 862-863

Intrinsic strength factors
aluminum 2S 1221
influence of plastic strain 1222-1223
copper 1221
duralumin 1221
effect of plastic strain 1220, 1222-1224
effect of temperature 1220, 1222-1224
Monel 1221
nickel 1221

Invar
carbon solubility in austenite 1084
effect of temperature 1085
lattice parameter versus carbon content 1085
Curie temperature
effect of carbon content.. 1089-1090
dimensional changes 1074-1077, 1079, 1081-1085, 1093
aging at various temperatures 1074-1075
annealed material 1079
aging following quenching from various temperatures 1075-1077
effect of cooling rate 1079
effect of heat treatment.. 1082-1083
effect of residual stresses and stress relief 1081-1084, 1085, 1093
effect of shock treatment 1082-1084
multiple aging 1077
expansion coefficient 1073-1075, 1079-1081, 1091-1093

Invar (cont.)
expansion coefficient
effect of carbon content.. .....1073, 1080
effect of cold working ... 1073
effect of cooling rate 1073, 1079-1080
effect of heat treatment.. .....1073, 1091-1093
effect of room temperature aging 1073
length measurements 1074
progressive change ..1073, 1075
specific volume versus length 1081
transitory change ..1073, 1075
γ-expansion 1075, 1077-1079, 1093-1095
correlation with precipitation 1087-1089
effect of multiple aging 1077-1079, 1094
effect of carbon content 1080, 1094
effect of cooling rate 1079
hardness changes accompanying 1089-1090, 1094
magnetic changes accompanying 1089-1091, 1094
X-ray measurements during 1088-1089, 1094
literature survey 1072-1073
occurrence of graphite 1085-1087, 1095
stabilization treatment 1092, 1095-1096
thermal expansion coefficients 1090-1092
effect of minor elements 1091-1092
methods of measurement 1090
Young's modulus 1082

Iron
effect on properties of ductile zirconium 903
lattice parameter 435

Iron carbide
crystal structure 379

Iron-chromium
constitution diagram 142-143, 827

Iron-molybdenum
constitution diagram 825-826

Iron-nitrogen
phases 379-380, 389-390
crystal structures 379-380
diagram 380

Iron ore smelting 651-691
African one-man furnaces 662, 664-666
capacity
United States, 1901-1950 662
World, 1950 664
carbon hearth 678, 680
direct reduction 666-667
Brassert-Cape furnace 666-667
diagram 667
Wiberg furnace 669-670
Domnarvet furnace 669
effect of moisture in air blast on composition 686-687
firebrick-lined furnaces ..675-678
lining problems 676, 678
gas studies 684-688
gas index 686
Messerle equation 684-686
history 651-662
anthracite furnaces 658-659
by-product coke ovens 659-662
Catalan forge 653-654
Catasauqua furnace 658
Duquesne revolution 659
Elban forge 652-653
pit cole furnace 657-658
Saugus furnace 654-656
stone-walled furnaces 656-658
Krupp Renn furnace 667-669
Luppen 668
ore beneficiation 670-671, 674
pelletmaking 670-671
desirable characteristics 671
sintering 670
southern ore 670-674
concentration process 674
ore deficiencies, 1950-1970.. 676
ore requirements, 1950-1970 675
ore reserves, 1950 677
ore supplies, 1950-1970 676
ore supply problem 674-675
pressure operation 680-684
blast furnace alterations for 683

Iron ore smelting (cont.)
production
United States, 1901-1950 662
World, 1937, 1948 664
raw materials to finished products—1948 663
slags 688-689
madisonite 689
United States
interests in foreign ores.. 677
ore deficiencies 676
ore requirements 675
ore reserves 677
ore supplies 676
ore supply problem 674-675

Iron oxides
formed at various temperatures 427

Iron percarbide 379

Isothermal transformation
in chromium-molybdenum-manganese steels
compositions 719
effect of alloying elements 725-727, 730, 732
experimental procedure 719-721
hardness data 720, 725-729
TTT diagrams of 725-729
in nickel-chromium-molybdenum steels
composition 719
effect of alloying elements 723, 730-732
experimental procedure 719-721
hardness data 720-725
photomicrographs 724-727
TTT diagrams of 721-725
relationship to hardenability 730
relationship to slack-quenched structures 730-731

Jominy test
compared with new hardenability test 465-472, 479

Krupp Renn furnace 667-669

Latent energy
aluminum, 2S
influence of plastic strain 1232-1235

Latent energy (cont.)
aluminum, 2S
influence of temperature 1232-1235, 1237-1240
definition 1232
of stressed metals
effect of plastic strain on 977-986
latent energy ratio
influence of plastic strain on 977-986
latent energy relationships 975-977

Latent energy ratios
aluminum, 2S
influence of plastic strain 1232-1236
influence of temperature 1232-1240

Lattice constants
of magnet alloys
Alnicos 75, 80-81
Cunico 87, 90
Cunife 87, 90
Silmanal 90, 92-94
Vectolite 94-95
Vicalloys 95-96

Lattice strain
role in permanent magnetism 70, 76-77, 83-84, 87-99

Liquidus temperatures
in chromium-molybdenum-iron alloys 833-835
in indium-cadmium-zinc alloys 869-870

Luppen 668

Machinability
of silver chloride 58

Magnesium alloys
solidus temperatures
dilatometric determination of. See under Solidus temperatures.

Magnesium alloys, trade designation
AZ31X-h
hot forming 1013-1032

Magnesium alloys, trade designation (cont.)
FS-1 magnesium alloy
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C 547-570

Magnet alloys
Alnicos 71-85
Cunico 85-90
Cunife 85-90
Silmanal 90-94
Vectolite 94-95
Vicalloys 95-97

Magnetic measurements
in studying tempering of chromium steels .....
.....498, 500-502, 508-509

Magnetic susceptibilities
steels, high chromium ...188-190
effect of annealing temperature 188
effect of holding at sigma formation temperature 189-190

Magnetostriction
in permanent magnet alloys
..... 84, 98-99

Marble's reagent 200

Martensite
crystal structure 381

Measuring equipment
for rapid load tests
dynamometer 575
extensometer 575

Mechanical properties. See Properties.
aluminum alloys
Al-H12 613
Al-H18 613
2S-H12 613
2S-H18 613
4S-H32 613
4S-H38 613

Melting point
chromium 1098
titanium 1098

Messerle equation 684-686

Metallic characteristics
of silver chloride 39-69

Metallographic
study of cleavage surfaces in ferrite 937, 946-948

Metallographic analysis
of chromium-molybdenum-iron alloys 830-833
of indium-cadmium-zinc system 859-860, 864-868
of zirconium-iron system.892-896

Metallography
of chromium steels
use in studying tempering
.....503, 509-511, 521-525
of permanent magnet alloys
Alnicos 76, 79-80, 82-84
Cunico 87-88
Cunife 87-88
Silmanal 90-92
of silver chloride 46-48

Micellar theory
as explanation for fatigue 967-968
correlation with damping behavior 968

Microhardness
carbide particles in tool steels 1157
effect on grindability 1157
stainless steel, 19-9 W-Mo
sigma phase 235
steels, high chromium
constituents 173

Microstructure
of chromium-molybdenum-iron alloys ...837-838, 840-841, 843
of indium-cadmium-zinc alloys 866-868
of molybdenum coatings ... 111
of plain chromium steels ..
..... 761-762, 769

Modulus of elasticity
for ten engineering alloys 552-553

Moisture
as source of hydrogen in embrittlement of stainless steels
.....811-812, 814-821

Molybdenum
in aluminum-silicon alloy
effect on grain size 639
in aluminum-silicon-magnesium alloy
effect on grain size 640

Molybdenum-nickel alloys
constitution diagram 205

Molybdenum pentachloride
use in molybdenum plating 105-121

Molybdenum plating
adhesion of the plate 114-120
on copper 120-121
disadvantages of previous methods 106-107
microstructure 110-120
on nickel 115-121
possible usefulness of 105
properties of the plating 112-113, 118-120
on steel 115, 120-121
structure of the plate....110-114
study of plating procedure 107-110

Molybdenum-vanadium steels
Charpy impact
after exposure to elevated temperatures 333
elevated temperature tests 327, 330-332, 337
effect of heat treatment prior to welding on graphitization 331
graphite rating of welds 327, 330, 331, 337
oxidation 332

Monel
ultimate stress
effect of temperature 1217-1218

Murakami etch 164

Neumann bands
in silicon-ferrite 907-908, 910-927

Neumann lamellae. See Neumann bands.

Nickel
role in magnet alloys 77
ultimate stress
effect of temperature 1217-1218

Nickel-aluminum alloys
constitution diagrams ...201-202
identification of constituents 200-204
photomicrographs 203

Nickel-aluminum-molybdenum alloys 193-225
chemical analyses ..196, 213, 216
creep-rupture life versus tensile strength 215
creep-rupture properties 194-199, 215-216
effect of cobalt 199
effect of molybdenum ... 196
effect of nickel to aluminum ratio 196
effect of tungsten 199
influence of composition variations 194-199
influence of solution treatment 211-212
time versus per cent elongation curves.198-199, 212, 214
elevated temperature properties 215-218
effect of molybdenum on 196
fatigue 224
etchants 200
hardness
of solution-treated and aged specimens 209-211
identification of constituents 200-207
metallographic characteristics 199-207
microstructures
effect of cobalt 211
effect of heat treatment 207-209
photomicrographs ..208, 210
nickel-aluminum ratio versus log rupture time 215-216
photomicrographs 206
rupture life 223
specifications (tentative) 218-220
tensile properties 217

Nitriding
atmosphere 346
process 346
relation to carburizing and carbonitriding 344-348
temperature 346
time 346

Nitrogen
in cementite 394
in chromium steels
effect on toughness .....
.....764-769, 771-777
as function of heat treatment temperature 773-777
in stainless steel, AISI type 446
effect on expansion properties 245
effect on grain size 244
effect on tensile properties 244

Nitrogen-iron. See Iron-nitrogen.

Notches
effect on properties of ten engineering alloys
alloys tested 548-549
Charpy keyhole impact values at room and lower temperatures 567-568
equipment and procedure 549-552
fatigue properties at 25 °C and —196 °C
fatigue (S-N) curves.556-561
notch sensitivity 562-566
resistance to overstressing 556, 562
summary of endurance limits 556, 558-561
tensile properties at 25 °C and —196 °C 552-555
modulus of elasticity values 552-553
Vickers hardness values at room and lower temperatures 567

Notch sensitivity
of ten engineering alloys at 25 °C and —196 °C 562-566

Nucleation equations
for transformation curves
in studying tempering of chromium steels.503-505, 508

Order-disorder
in magnet alloys
Vicalloy 95-96

Ore beneficiation 670, 671, 674
pelletmaking 670-671
desirable characteristics . 671
sintering 670, 671, 674
Spaulding concentrate process 674

Oxidation
iron
at 500 °C 436-437
at 600 °C 437, 440-442
at 700 °C 438, 441-442
at 800 °C 439, 440, 442
thickness of oxide versus oxidation time 442
at 900 °C 443
effect of humidity 446, 452
effect of silicon in iron on oxide film 444
effect of time and temperature 429-431
literature survey 426-428
composition of oxides . 427
kinetics of the reaction 427
mechanism of reaction 428
structure of oxides ... 427
oxide films 431-443
diffraction patterns .433-434
identification 431-434
metallography 435-436
thickness 436
oxides formed at various temperatures 427-428
effect of thickness 427
relative thickness ..443, 450
parabolic rate law 427, 444
rate constant 427, 444
rate constant versus reciprocal of temperature.430-431
stainless steel, type 304
pretreatment to form preferential oxides 415-417
effect of oxygen concentration 416
effect of partial pressure of oxygen on rate..409-411
effect of temperature on rate 410-411
effect of time on rate 409-412

Oxidation (cont.)
stainless steel, type 410
effect of structure on oxidation characteristics 417-418
effect of temperature ..417-418
stainless steels .....
.....405, 410-411, 417-418
equipment for determining 406-407
literature survey 405-406
mathematical representation of rate law ...410, 417-419
exponent n versus temperature 418-419
procedure for determining 407-409
rupture of scales 411-413
effect of composition on time for rupture...412-413
effect of rate of oxide formation 411
variation with temperature.405
equation 405

Oxidation tests 1114-1117
stainless steels 1116
type 304 1116
type 316 1116
titanium-chromium alloys
.....1114-1118

Oxides
stainless steel, type 304....
.....413-415, 421
composition 414-415, 421
effect of oxidation time 414
stainless steel, type 430.... 415
composition 415
effect of oxidation time 415

Pearlitic steels
Charpy impact 1181
effect of alloying elements 1183-1186, 1189-1200
impact energy versus temperature 1187-1188
maximum energy versus reduction in area of tensile test 1196
shape of transition curves 1197
effect of alloying elements ...1187, 1197, 1199
effect of carbon .....
.....1187, 1197-1198

Pearlitic steels (cont.)
Charpy impact
shape of transition curves
effect of manganese...
.....1198-1199
effect of nickel ...1187, 1198
effect of phosphorus ..
.....1187, 1198
effect of silicon...1187, 1198
transition temperatures
.....1182-1189
additivity of composition effects 1193-1194
additivity of effects of manganese and carbon....1195
definition 1182, 1187
effect of aluminum 1189
effect of boron 1190
effect of carbon .....
.....1187, 1190, 1207, 1211
effect of chromium ...
.....1190, 1205, 1211-1213
effect of cobalt .....
.....1190, 1211, 1213
effect of composition ..
.....1182, 1187, 1191
effect of copper 1190
effect of manganese ...
.....1190, 1205, 1207
effect of manganese-carbon ratio 1194, 1196, 1208
effect of molybdenum
.....1190, 1205, 1213
effect of nickel .....
1187, 1190, 1207, 1210, 1214
effect of nitrogen 1211
effect of phosphorus ..
1187, 1191-1192, 1202, 1211
effect of silicon .....
1187, 1192-1193, 1202, 1211
effect of sulphur 1192
effect of tensile strength
.....1195-1197
effect of titanium 1193
effect of vanadium ....
.....1193, 1202, 1211
mechanisms by which alloying elements may change ...1199-1200, 1207
versus reduction of area of tensile test...1196-1197
composition 1176-1179, 1212

Pearlitic steels (cont.)
effect of sulphur on lowest temperature of lamination 1192
effect of sulphur on per cent lamination
grain size 1177-1181
per cent pearlite .1177-1179, 1181
temperatures of transformation 1177-1182
tensile properties 1182-1186

Permanent magnetism
theory regarding .....
.....70, 74, 76-77, 84, 97-99

Phase diagrams. See Constitution diagrams.

Photomicrographs
of nickel-chromium-molybdenum steels during isothermal transformation 724-727

Plastic deformation
associated with cleavage surfaces in ferrite 937-952

Plastic flow
equations 1035, 1045
theory 1034-1036

Plastic strain
in stressed metals
effect on intrinsic strength 971-975
influence on latent energy and the latent energy ratio 977-986

Plating
molybdenum. See Molybdenum plating.

Post test
compared with new hardenability test 465-472

Powder metallurgy
beryllium 1052-1069
bend tests of sintered compacts 1063-1064
electrical resistivity of specimens 1064
cold rolling of sintered compacts 1064-1067
effect of annealing.1065-1066

Powder metallurgy (cont.)
beryllium
cold rolling of sintered compacts
influence on microstructure 1065
compacting 1056
effect of pressure on density 1056
electrical resistivity of sintered 1060
hardness of sintered compacts 1067
metallography of compacts 1068
microstructures of sintered compacts 1060-1063
effects of sintering temperature 1061-1062
particle size 1054-1055
purity 1054-1056
sintering 1056-1060
in argon 1057
effect of sintering temperature on density..1057-1058
effect of sintering temperature on electrical resistance 1057, 1060
evaporation of beryllium 1059-1060
in vacuum 1057
twinning 1065-1066

Precipitation
role in magnet alloys
Alnicos 73-85
Cunico 85, 87-90
Cunife 85, 87-90
general theory 70, 97-99
Silmanal 90-94
Vectolite 94-95
Vicalloys 95-97

Preferred orientation
carbonitrided case
epsilon phase 389-390

President's Annual Address.. 7

Prestraining
versus retained ductility of steel 778-792

Properties
of Alcoa aluminum alloy 52S
after stretching 124-129

Properties (cont.)
effect of hot forming on mechanical properties
of aluminum alloy 75S-T6 1015-1017
of magnesium alloy AZ31X-h 1015-1017
of molybdenum coatings 112-113, 118-120
of permanent magnet material 72
of plain chromium steels
tensile and impact 761-777
of silver chloride
elastic constants 55-58
mechanical 55-58
physical 62-63
of ten engineering alloys at 25 °C and −196 °C
Charpy keyhole impact.567-568
tensile and fatigue, both notched and unnotched 552-556
Vickers hardness values.. 567
transverse ductility of wrought steel products
effect of reheat treatment on. See Reheat treatment.
of zirconium-iron alloys
heat resistance ...899-901, 903
hot strength 899, 903
tensile data 898-899
workability 903

Puron
composition 428

Quenching
three stages in 490-492

Quenching constant, H. See H factor in hardenability of steels.

Rapid load testing
arrangement for controlled temperature tests 574
circulating unit 575
alcohol cooling 575
oil heating 575-576
equipment 572
photograph 572
measuring equipment 575
dynamometer 575
extensometer 575

Rapid load testing (cont.)
period of constant plastic deformation rate 581
plastic deformation
delay time for initiation.581-585
effect of stress 582
delay time versus stress relation 582-585
effect of temperature.583-585
procedure 571-576
relation between logarithm of delay time and applied stress 582-585
specimen 576
heat exchanger 573-575
static upper yield stress..583-585
typical record of 581

Recovery
of Alcoa aluminum alloy 52S 122-138
definition of 122-123
results of 122

Recrystallization
of Alcoa aluminum alloy 52S 127-138
of silver chloride 51-52

Reheat treatment
effect on transverse ductility of wrought steel products
calculation of standard deviations 530
composition of tubes and forgings 527
heat treatments employed 527-528
material tested 527-528
other possible advantages of reheat treatment ...542-543
reasons for not reheat treating 543-545
relationship to product acceptability 542
reliability of conclusions 539-542
results and their interpretation
multiple heat treatments 530-532, 539
requench and temper groups of forgings or tubes 530-532, 536-537

Reheat treatment (cont.)
effect on transverse ductility of wrought steel products
results and their interpretation
requench and temper heats of tubes ..530-532, 537-539
requench and temper individual forgings or tubes 530-536
retempering groups of forgings 530-533
retempering individual forgings 530-532
summary of results ..543-545
test procedure 529-530

Residual induction
definition of 72
of permanent magnet materials 72

Rheotropic embrittlement of steel
definition 779-781
effect of tempering temperature on ductility ..782-783, 785-792
effect of tempering temperature on fracture stress 787-792
heat treatment of material 803-804
material used 802-803
of notched specimens ...801-802
purpose of investigation..781-783
retained ductility versus prestrain
definition of retained ductility 778-779
heat treated SAE 1340 steel 783-792
three portions of curves.. 781
two basic types of behavior 779
specimens and test procedure 804-805
and transition temperature of annealed steels ...795-801
drawing versus prestretching 800-801
and transition temperature of SAE 1340 steel 792-795

Rolling
of Alcoa aluminum alloy 52S
recovery and recrystallization after 122-138

Seamless tubes
steel
effect of reheat treatment on transverse ductility. See Reheat treatment.
mechanical properties
effect of alloying elements 1129-1137
effect of carbon ...1130-1131
equations 1130
effect of manganese 1130, 1132
equations 1130
effect of molybdenum.. 1135-1136
effect of nitrogen 1138-1139, 1142-1143
effect of phosphorus 1130, 1133
equations 1130
effect of silicon 1130-1132, 1134
equations 1132
effect of titanium .1132-1135
regression equation ... 1136

Secretary's Annual Report ... 15

Sensitization
stainless steels
definition 293

Sigma phase
in chromium-molybdenum-iron alloys 833-834, 841-847
chromium-nickel-molybdenum steel
effect of aging time ...164-165
microstructures 163-165
effect of aging temperature 164-165, 167
effect of molybdenum ... 166
manner of growth 168
relation to apparent ferrite content 165-166
transformation of ferrite 166-167
embrittlement 162
etchants for detecting 164
stainless steel, 19-9 W-Mo
Debye diffraction patterns 234-235
literature survey 226-227

Sigma phase (cont.)
stainless steel, 19-9 W-Mo
magnetic intensity to detect 232-233
effect of aging temperature 232-233
effect of aging time..232-233
effect of solution treatment 232-233
effect of strain hardening 232-233
magnetic measurements for detecting 228
mechanism of formation 232-233, 235, 237-242
microhardness 235
microstructure 229-232
effect of aging temperature 229-232
effect of aging time..229-232
effect of solution treatment 231-232
effect of strain hardening 229-231, 236
steel, chromium
embrittlement 158
solubility of carbon in..150-151
wrought heat resisting steel, 19-9 W-Mo 226-242

Sigma phase formation
steels, high chromium 173-186, 189-190
effect of age hardening.173-174
effect of alloying elements 174-175
effect of composition on temperature range 176
effect on macrohardness. 173
effect of manganese on tendency 176
effect of molybdenum on temperature range 176
effect of stability of austenitic matrix 189-190
rate
comparison of cast and wrought material 183-184, 186
effect of annealing ..180, 186
effect of cold work..178, 185
effect of ferrite 176-178

Sigma phase formation (cont.)
steels, high chromium
rate
effect of manufacturing variables 181-184, 186
effect of rate of solidification 182-184
effect of repeated recrystallization 185
effect of rolling temperature 181-182, 186
influence of carbon ... 175
influence of free energy 174
influence of nitrogen .. 175
relation to ferrite in initial structure 174
temperature dependence 179
threshold time 145, 148-150, 153-154, 156-158
effect of carbon.153-154, 156
effect of chromium.... .....147-149, 154, 157-158
effect of cold work ... .145, 149-150
effect of manganese ... 154
effect of pretreatment 159-160
effect of silicon 154
effect of temperature 148-149
temperature of minimum 149

Silicon-ferrite
study of fracture of crystals.
See under Fracture.

Silver chloride
analogy to metals permitting use as transparent metallurgical tool
alloying of silver chloride 58-61
castings 48-51
cold-worked silver chloride 51
crystal structure and allotropy 58
dissimilarities 63-64
fabrication 45-46
machinability 58
mechanical properties and elastic constants 55-58
melting and casting 41-45
metallography 46-48
physical properties 62-63
recrystallization 51-52
stress relief anneal 52-54

Slip planes
in fractured ferrite 952-953

Solidus temperatures
dilatometric determination for magnesium alloys
apparatus employed ...873-874
comparison with published results 884-886
compositions of alloys used 874
determination of coefficient of expansion ...877, 880-886
dilatometer curves 874-879
interpretation of curves 875-886
effects of creep 880-886
factors controlling creep 881-883
first derivative of dilatometer curves 874-886
results for magnesium-aluminum alloys 879-882
results for magnesium-zinc alloys 882-884
solvus temperatures ..880, 883

Solvus temperatures
in magnesium alloys
dilatometric determination of. See under Solidus temperatures.

Spaulding concentrate process 674

Specific volume measurements
in studying tempering of chromium steels 511-512

Spectrophotometer
use in measuring absorption spectrum of silver chloride 42-43

Stainless steels. See also Ferritic stainless steels.
Class I type
embrittlement during heat treatment
compositions of steels tested 813
effect of normal moisture and steam 814-821
magnetic intensity
apparatus for measuring 228

Stainless steels (cont.)
oxidation 404-420
activation energy..405, 419-420
equations 405
18-8S stainless
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C 547-570

Stainless steel, trade designation
19-9 W-Mo
sigma-phase formation 226-242
type 304
carbide form
effect of cold work ..310-312
effect of heat treatment 310-312
effect of interrupted quench from annealing temperature 302
effect of sensitization time 299, 305-307
photomicrographs 299-300, 303-304, 306-307, 311
carbide precipitation in 290-322
compositions 292, 408
cooling versus heating to sensitization temperature on rate of carbide nucleation 302-305
corrosion resistance
effect of interrupted quench from annealing temperature 305
effect of cold work and heat treatment on corrosion rate 310-312
effect of sensitization temperature on carbide form 294-300
effect of sensitization temperature on corrosion rate 294-299
effect of time of sensitization on carbide form 299
electron photomicrographs 299-300, 303-304, 306-307, 311
electron photomicrographs 295-297, 299-300, 303-304, 306-308, 311, 315
locus of carbide precipitation 308-309

Stainless, trade designation (cont.)
type 304
locus of carbide precipitation electron photomicrographs 308
method of carbide isolation 293
sensitization by interrupted quench from annealing temperature 305-306
type 410
composition 408
type 430 .....245-246, 248-249
composition 246, 408
critical points 249
expansion properties 248-249, 258-259
effect of austenite on 248-249, 258-259
type 446 243-259
austenite-forming elements in 244, 248
austenite phase 244-245, 247-248, 251, 254
effect of composition 245, 251, 254
effect on expansion properties 247-248
effect of temperature 251, 254
influence of nitrogen .. 244
treating temperature versus available chromium to form 251, 252
chromium equivalent of impurity elements ...252-253
comparison of multiplying factors 253
commercial applications 243-244, 254-255, 258-259
composition 243, 245, 248
effect of nitrogen on expansion properties .. 245
effect of nitrogen on grain size 244
effect of nitrogen on tensile properties 244
expansion characteristics 243-245, 257-259
effect of austenite formation on 247-248, 257-259
ferrite-forming elements in 244, 248

Stainless, trade designation (cont.)
type 446
ferrite/ferrite-austenite boundary
effect of composition .. 252
effect of temperature .. 252
grain size
effect on nitrogen 244
high temperature oxidation resistance 243
microstructure 246-251, 256-257
effect of carbon 249
effect of manganese ... 249
effect of nickel 250
effect of silicon 250
effect of temperature on 249-250, 256-257
tensile properties
effect of nitrogen 244

Static stress versus strain
mild steel
effect of temperature ..577-580

Static tension
test procedure 576-577

Statistical analysis
seamless steel tubes
effect of alloying elements on mechanical properties 1126-1137
effect of 0.01% increment of various elements .. 1136
literature survey ..1126-1127
procedure 1129

Steam
in heat treating atmospheres
embrittling effect on stainless steels 814-821

Steel
activation energy for isothermal grain growth 279-280
aluminum coating of 587-605
austenite grains
effect of shape on growth 281-285, 288-289
influence of time at austenitizing temperature on shape 279-285
austenitizing time vs. reciprocal absolute temperature 281

Steel (cont.)
chromium. See Chromium steels, plain.
tempering of. See under Tempering of.
chromium-molybdenum-manganese
isothermal transformation. See under Isothermal transformation.
coarse grain type
influence of austenitizing temperature on grain size ...263, 268-269, 271, 275, 284
influence of austenitizing time on grain size 263-267, 275, 284
isothermal austenite grain growth 277
deep hardening
hardenability test. See Hardenability test.
fine grain type
influence of austenitizing time on grain size 263-266, 269-275, 284
photomicrographs 264
grain growth, rate of
influence of austenitizing temperature 279-280
influence of grain size 278-280, 284
grain size (austenite)
influence of austenitizing temperature 260-285
influence of austenitizing time 263-285
photomicrographs 264
influence of carbides ..277, 285
influence of deoxidation practice 273-276, 285
influence of inclusions 273-276, 285, 289
influence of nitrogen 276
influence of the steelmaking process 276, 285
isothermal growth in coarse-grained steels ..277-278, 285
relation between grain coarsening and residual aluminum 274-276, 285
graphitization 692-711

Steel (cont.)
H factor. See H factor in hardenability of steels.
Hy-Tuf steel
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C 547-570

Steel, mild
nickel-chromium-molybdenum
isothermal transformation. See under Isothermal transformation.
rheotropic embrittlement in. See Rheotropic embrittlement of steel.
strain hardening characteristics at low temperature ..1033-1050
temper brittleness. See Temper brittleness.
time delay for yielding ..571-586
influence of temperature 571-586

Steel, trade designation
NE 8630
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C 547-570
SAE 1010
fractographic study of fatigue 958-959, 966-967
SAE 2330
tensile and fatigue properties
effect of notches on at 25 °C and —196 °C 547-570
SAE 3140
composition 645
effect of strain rate on ductility 644-650
effect of strain rate on transition temperature 644-648
energy absorption versus test temperature 646
Charpy impact 646-648
slow bend test 645-648
SAE 4130
fractographic study of fatigue 958-959, 967

Steel, trade designation (cont.)
SAE 4340
tensile and fatigue properties
effect of notches on at 25 °C and −196 °C 547-570
wrought
effect of reheat treatment on transverse ductility. See Reheat treatment.

Strain aging
aluminum
high-purity 1219
2S 1218-1219
brass 1218-1219
copper 1218-1219
duralumin 1218-1219
effect of temperature 1219
literature survey 1215-1216
Monel 1218-1219
nickel 1218-1219

Strain energy
aluminum, 2S
influence of temperature 1229, 1231, 1237-1240
variation with plastic strain 1229, 1231
of stressed metals
effect of temperature on 986-991
total strain energy relationships 975-977

Strain rate
SAE 3140 steel
effect on transition temperature 644-648

Strength
intrinsic strength of metals
as affected by plastic strain and temperature 971-975

Stresses, biaxial tension-compression
applied to aluminum alloys 2S-O and 24S-T
effect on mechanical behavior 993-1012

Stress relief
of silver chloride 52-54

Stress rupture
specimen 614

Stress rupture (cont.)
titanium-chromium alloys 1114-1115

Stress-strain
energy relationship for metals
fundamental stress-strain energy relationship ..990-991
influence of plastic strain on latent energy and the latent energy ratio ..977-986
influence of temperature on flow stress 975
influence of temperature on strain energy 986-991
intrinsic strength as affected by temperature and plastic strain 971-975
total strain energy, work hardening energy and latent energy 975-977

Stress-strain curves
for silver chloride 40, 54-56

Stress-strain energy relations
for various strength states 1228-1231
influence of temperature 1229-1231

Stress-strain relations
for biaxial tension-compression of aluminum alloys 2S-O and 24S-T
constant stress ratio test results 1001
determination in terms of simple tension values 994
elastic combined stress-strain relations ..1002-1004
generalized deformation theory for ..994-995, 1011
generalized stress-strain relations 1008-1009
material tested 995-996
mechanical properties 995-996
method of measuring strains 998-999
methods of testing 999
plastic combined stress-strain relations ..1004-1007
production applicability of relations 993-994

Stress-strain relations (cont.)
for biaxial tension-compression
of Al alloys 2S-O and 24S-T
tension test results..999-1000
testing machine 996-998
test specimens used ... 996
variable combined stress
test results 1009-1010

Stretching
of Alcoa aluminum alloy 52S
recovery and recrystallization
after 122-138

Structure
of molybdenum plate 110-120
of permanent magnet alloys
Alnicos 74-75
Cunico 86-89
Cunife 86-89
Silmanal 92-94
Vectolite 94-95
Vicalloys 95-96

Surface tension
grain boundary
equations for changes in
.....735-738

Tantalum
in aluminum-silicon alloy
effect on grain size 639
in aluminum-silicon-magnesium
alloy
effect on grain size 640

Technical Program and Reports of Officers, ASM—32nd Annual Convention, Chicago, October 21 to 27, 1950 1

Temper brittleness
in steel
theory of mechanism ..739-747
effect of alloying elements
.....741-742
typical microstructures
.....742-744

Tempering of
chromium steels
hardness changes 515
effect of chromium on
.....514-516, 521, 524

Tempering of (cont.)
chromium steels
materials investigated 498-499
structural components of
.....499-500
structural changes during
first stage 497-498
definition of first stage
.....497-498
structural changes during
fourth stage 509-516
definition of fourth stage 498
electrolytic isolation of
the carbides 512-515
electron microscopy of
.....510-511, 518-519
heat of activation of
decomposition 513
metallographic study of
.....509-511, 521-525
specific volume measure-
ments in studying..511-512
structural changes during
second stage .....
.....498-509, 515-516
decomposition equations
.....503-505
definition of second stage
..... 498
dilatometer measurements
in studying 499-502
heat of activation of
decomposition 504, 508
magnetic measurements
in studying 500-502
metallographic study of
.....503, 521-525
structural changes during
third stage ...498-509, 516
decomposition equations
.....503-505, 508
definition of third stage
..... 498
dilatometer measurements
in studying .....
.....499-502, 505-508
heat of activation of
decomposition 504, 508
magnetic measurements
in studying .....
.....500-502, 508-509

Tempering of (cont.)
chromium steels
struct. changes during 3rd stage
metallographic study of
.....503, 521-525
steel
effect of temperature on
ductility 782-783, 785-792
effect of temperature on
fracture stress 787-792

Tensile properties
at low temperatures
of ten engineering alloys,
notched and unnotched
.....552-555
nickel-aluminum-molybdenum
alloys 217
pearlitic steels 1182-1186
stainless steel, type 446.... 244
effect of nitrogen 244
titanium-chromium alloys ..
.....1111-1114

Tensile strain
relation to torsional strain..
.....1035-1036

Tensile stress
aluminum 2S
influence of plastic strain..1222

Tensile test
strain hardening exponent
variation with temperature
.....1048-1049
strength coefficient
variation with temperature
.....1047-1048

Tension-compression biaxial stresses
applied to aluminum alloys
2S-O and 24S-T
effect on mechanical behavior
.....993-1012

Testing for
H factor in hardenability of
steels 480-496

Tests
bar-bend test
use in studying embrittlement
of stainless steel
by normal moisture and
steam 814-821

Tests (cont.)
hardenability. See Harden-
ability test.
Jominy. See Jominy test.
Post. See Post test.

Thermal analysis
of chromium-molybdenum-iron
alloys 829-830, 833-842
of indium-cadmium-zinc alloys
.....857-862, 868-870
of zirconium-iron system.892-896

Thermal conductivity
use in determining H factor
.....480-496

Thermal diffusivity
use in determining H factor
.....480-496

Thermal expansion coefficients
Invar 1072-1096

Thermal treatments
of chromium-molybdenum-iron
alloys
effect on solid phase dis-
tribution 834-842

Thermodynamics
of interfaces 735-738

Titanium
in aluminum-silicon alloy
effect on grain size....639, 642
in aluminum-silicon-magnesium
alloy
effect on grain size 640-642
density 1098
melting point 1098
role in magnet alloys 79-80
tensile and fatigue properties
effect of notches on at 25
°C and —196 °C 547-570

Titanium-chromium alloys
arc furnace melting .....
.....1100-1102, 1107-1110
chemical purity of alloys
.....1108-1110
crucibles 1102, 1107
Charpy impact 1114-1115
diffraction patterns 1121
forgeability 1104, 1108

Titanium-chromium alloys (cont.)
forgeability
method 1104
range 1108
temperatures 1108
gas contents
methods of analyses 1104
hardness 1110-1111, 1113
effect of annealing...1110-1111
effect of forging.....1110-1111
effect of quenching temperature 1110, 1113
hot hardness 1104-1105, 1110-1111
forged alloys 1110-1111
methods 1104-1105
induction furnace for melting 1100-1101
literature survey 1099-1100
methods of preparation 1103-1104
oxidation tests 1114-1117
effect of composition 1115-1118
effect of testing temperature 1115-1117
effect of time 1116, 1118
refractory crucibles for induction melting .1102, 1106-1107
effect on ingot composition 1106-1107
stress-rupture properties 1114-1115
structures 1117-1122
effect of composition.1117-1122
effect of treatment ..1118-1122
tensile properties 1111-1114
effect of composition.1113-1114

Tool steels
compositions 1147
finishability 1163-1165
grindability 1144-1174
grindability index 1151, 1154-1165

Torsional strain
relation to tensile strain 1035-1036

Torsion test
apparatus 1037-1039
effective stress versus effective strain 1045-1046
steel, mild
fractures 1043-1045
effect of temperature.. 1043-1045

Torsion test (cont.)
steel, mild
mechanical properties ... 1041
torque versus twist..1040-1043
effect of temperature.. 1040-1043
twist versus time 1042
effect of temperature.. 1042-1043
yield point twisting..1041-1042
strain gages 1037-1039
strain hardening exponent
variation with temperature 1048-1049

Transformation - temperature - time diagrams for steel. See also Isothermal transformation.
chromium-molybdenum-manganese steels 725-729
nickel-chromium-molybdenum steels 721-725

Transition temperature
of annealed steels
and rheotropic embrittlement 795-801
of SAE 1340 steel
and rheotropic embrittlement 792-795
SAE 3140 steel
effect of strain rate ...644-648

Transparency
of silver chloride 42-45
effect of chlorination on..43-45
effect of fluorescent lighting on 42-43

Treasurer's Annual Report .. 11

Tubes
seamless steel
effect of reheat treatment on transverse ductility. See Reheat treatment.

Tungsten
in aluminum-silicon alloy
effect on grain size 639
in aluminum-silicon-magnesium alloy
effect on grain size 640

Ultimate stress
aluminum
effect of temperature 1217-1218
aluminum 2S
effect of temperature 1217-1218
brass
effect of temperature 1217-1218
copper
effect of temperature 1217-1218
duralumin 24S-T
effect of temperature 1217-1218, 1220
Monel
effect of temperature 1217-1218
nickel
effect of temperature 1217-1218
slope of curve
influence of direct temperature factor 1220-1221
influence of intrinsic strength factor 1220-1222

Vanadium
role in magnet alloys 95-96

Vilella's reagent 164, 177, 200

Wiberg furnace 669-670

Workability
of zirconium-iron alloys ... 903

Work hardening energy
aluminum 2S
influence of temperature 1231, 1237-1238
influence of plastic strain 1231
relationship of stressed metals 975-977

Wrought steel
effect of reheat treatment on transverse ductility ...526-546

X-ray
diffraction analysis
of chromium-molybdenum-iron alloys 831-834, 840-842
of indium-cadmium-zinc alloys 860-867

X-ray (cont.)
study of cleavage
of silicon-ferrite crystals 912-921
study of cleavage surfaces in ferrite 935-953
study of magnet alloys
Alnicos 73-75, 79
Cunico 86-87
Cunife 86-87
Silmanal 90, 92
Vectolite 94-95
Vicalloys 95-96
study of recrystallization in Alcoa 52S alloy 127-131, 133-135
study of zirconium-iron system 894-897

Yield stress
aluminum 2S
effect of temperature 1217-1218
duralumin 24S-T
effect of temperature 1217-1218, 1220

Young's modulus
Invar 1082

Zirconium
in aluminum-silicon alloy
effect on grain size..... .....639, 641-642
in aluminum-silicon-magnesium alloy
effect on grain size 640

Zirconium-iron alloys
constitution diagram 901-903
development of 888-901
effect of iron on properties 903
heat resistance 899-901, 903
hot strength 899, 903
tensile data
for cold-worked alloys .898-899
for drawn alloys 898
for hot-rolled alloys 898
for quenched alloys 898
workability 903